The preparation, structure and magnetic separation characteristics of high-ferric and low-alkali content red mud

Hui-bin Yang[1], Shu-zhen Zhang[2], Xiao-lin Pan[3]
1. Chief engineer of alumina research institute, Zhengzhou Non-ferrous Metals Research Institute Co., Ltd of CHALCO, Zhengzhou China
2. Senior engineer of chemical alumina, Shandong Research Institute of CHALCO, Zibo 255051, China
3. Director of department of nonferrous metals, School of Metallurgy, Northeastern University, Shenyang 110819, China

Corresponding author：yhuibin@126.com

Abstract

The red mud, obtained from high-ferric gibbsitic bauxite digested in alkaline solution with atmospheric pressure, has loose structure and small particle size. Besides, the contents of Fe_2O_3 and Na_2O in the low-alkali red mud are 64.74% and 1.25%, respectively. And Goethite and hydrated hematite account for a large proportion, the latter coming from the hydration reaction in bauxite digestion process. This research aims to study the mineral structure and magnetic concentration properties of one kind of high-ferric and low-alkali red mud, using several modern testing methods such as X-ray diffraction (XRD), scanning electron microscopy (SEM), infrared spectroscopy (IR) and Brunauer–Emmett–Teller (BET) surface-area measurements. Analysis demonstrates that the suitable magnetic field intensity is 6000 GS, under which condition, the yield of concentrate is 46.42% and the Fe accounts for 52.84%. Besides, the concentrate have lower Na_2O content and higher Fe_2O_3 content, which can be used for the raw material of ironworks.

Keywords: high-ferric and low-alkali, red mud, atmospheric pressure digestion, structure, magnetic separation.

1. Introduction

Red mud, one kind of alumina industrial residue, is produced after gibbsitic bauxite digested in the Bayer process. Hematite, goethite and desilication product (DSP) are the main components of red mud in the traditional Bayer processred mud. In addition, red mud also contains a small amount of other mineral components like boehmite, quartz, anatase, and so on. The traditional digestion temperature and pressure are 145 °C and 5 kg/cm^2, respectively. DSP, produced in the digestion process, is hard to separate. Traditional Bayer red mud contains 8-15% Na_2O, which pollutes water, soil, and atmosphere. And this is the reason why red mud cannot be used widely. According to the statistics, the annual output of red mud is more than 70,000,000 tons in the world. How to deal with red mud is always one global problem [1, 2].

The research of traditional Bayer red mud focuses on iron selection [3, 4], as a building material or filler [5], recycling valuable components or elements [6-8] and so on. Literatures show that Bayer red mud also can be used for mineral thickening material or filling in cement [9, 10], made into non-sintering brick and porous ceramic filter ball [11, 12]. Besides, in some area, the red mud may contain higher scandium (Sc), which can be used to extract Sc_2O_3 by solution extraction [13]. In addition, the Al_2O_3 and Na_2O can be recovered from red mud in the sintering process red mud, and Central South University has studied how to extract Al_2O_3 from red mud by sintering process [14].

Xinqin L. and Laishi L. declared that sintering process could be used to extract Al_2O_3 from red mud high-efficiency and Bayer-sintering series process was the best process to deal with low grade bauxite [15, 16]. Jiadong H. etc. studied the technic of extracting alumina from red mud in lab [17]. Besides, some researchers even studied the sintering process like sintering temperature, desilication confluence position, sintering thermal regulation, composition of the clinker and so on [18, 19].

Fe_2O_3, as the maximum component in the red mud which makes extract iron from red mud, has been the main research direction. Guangxi Pingguo alumina refinery began to work on research of the Bayer red mud separation iron technology in 2008, whose industry production line were built in June 2011 and the pulsating high gradient two-stage magnetic separation technology were used in the item. The iron (Fe) content of concentrate can reach 55%, which can be used for the raw material of iron refinery. Yingbang X. et al. also studied reduction smelting iron separation technology of the Pingguo red mud [20], in which Red mud and coke mixed together to smelt, with the ratio of coke vs red mud to be 2.65, and the recovery ratio of the Fe can reach 97%.

Yanfei Z. applied hydrophobic agglomeration and magnetic seed iron separation technology to deal with Bayer red mud [21]. The iron content of the red mud sample is about 24% and the effects of magnetic field intensity, stirring speed, dispersing agent, quantity of the magnetic seed, and flocculating agent on the magnetic separation were studied. Maybe the selective hydrophobic flocculation magnetic separation is the best method to deal with fine particle red mud, because the iron content of concentrate can reach 50.62% and the recovery ratio of Fe can be 45.97%. Qunhu X. et al. used coal powder to reduce Pingguo Bayer red mud, besides the magnetic separation was applied [22]. The iron content of concentration sample is 54.51% and the recovery ratio of the iron is 55.01%. Wenchen J. studied how to extract Fe_2O_3 and Al_2O_3 from red mud by soda-lime sintering process [23]. Wanchao L. etc. studied the technology of red mud reducing roasting with adding coal and magnetic separation. The metallization ratio of Fe_2O_3 can reach 96.98% and recovery ratio is 81.40%. The tailings of the magnetic separation can be used as building material [24, 25]. Qi D. used high gradient permanent magnet separation technology to deal with red mud [26]. The Fe_2O_3 content of concentrate can reach 69.28% and the recovery ratio of red mud and Fe_2O_3 are 24.96% and 58.12%, respectively. In addition, other researchers also studied how to separate Fe_2O_3 from red mud by some methods, like hydrothermal, calcination, reduction smelting, magnetic-separation and so on [27-29].

The red mud, produced in atmospheric pressure (normal pressure, digestion temperature is 95-105 °C), contains no or only less DSP. This red mud is suitable to comprehensive utilization for its higher Fe_2O_3 content and lower contents of Na_2O and Al_2O_3 [30]. The structure of red mud was studied through various detecting methods; besides preliminary magnetic separation tests were conducted. Those results can be used as the reference for red mud comprehensive utilization and the improvement of gibbsitic bauxite digestion technology.

2. Material and Methods

2.1 Material

High-ferric gibbsitic bauxite was selected to produce high-ferric red mud, which was obtained from Kalimantan, Indonesia. The sample was dried at 105 °C for 6 hours, and then crushed by a jaw crusher and roll-crushing mill. The particle size of final sample was between 0.5 and 1.0 mm. Detailed information of the sample are shown in Table 1, Table 2, and Figure 1.

Detection results show that main minerals were goethite and hematite in atmospheric pressure digestion red mud. A large amount of needle-shaped goethite crystal particles was observed. The hydrate hematite was found in the red mud, which due to the hematite hydration reaction during the atmospheric pressure digestion process.

The suitable magnetic field intensity for high-ferric red mud magnetic separation is 6000 GS. Under this condition, the concentrate yield was 46.42% and the Fe_2O_3 content of concentrate was 75.49% (converting into Fe accounts for 52.4%). The Fe_2O_3 content of concentrate increased compared with raw material, while the contents of SiO_2 and Al_2O_3 decreased. Particle size and structure of concentrate were larger and denser, while that of the tailings were just the opposite.

5. References

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